

Methods and apparatus for calculating electromagnetic scattering properties of a structure and for reconstruction of approximate structures

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(54) **Methods and apparatus for calculating electromagnetic scattering properties of a structure and for reconstruction of approximate structures**

(57) A CSI algorithm for reconstructing grating profiles is disclosed. Solving a volume integral equation for current density, \mathbf{J} , employs the implicit construction of vector field, \mathbf{F}^S related to the electric field, \mathbf{E}^S , and current density, \mathbf{J} , by selection of continuous components of \mathbf{E} and \mathbf{J} , \mathbf{F} being continuous at one or more material boundaries, so as to determine an approximate solution of \mathbf{J} . \mathbf{F} is represented by at least one finite Fourier series with

respect to at least one direction, x , y , and the step of numerically solving the volume integral equation comprises determining a component of \mathbf{J} , by convolution of \mathbf{F} , with a convolution operator, \mathbf{M} comprising material and geometric structure properties in both directions. \mathbf{J} may be represented by at least one finite Fourier series with respect to both directions. The continuous components can be extracted using convolution operators, P_T and P_N , acting on \mathbf{E} and \mathbf{J} .

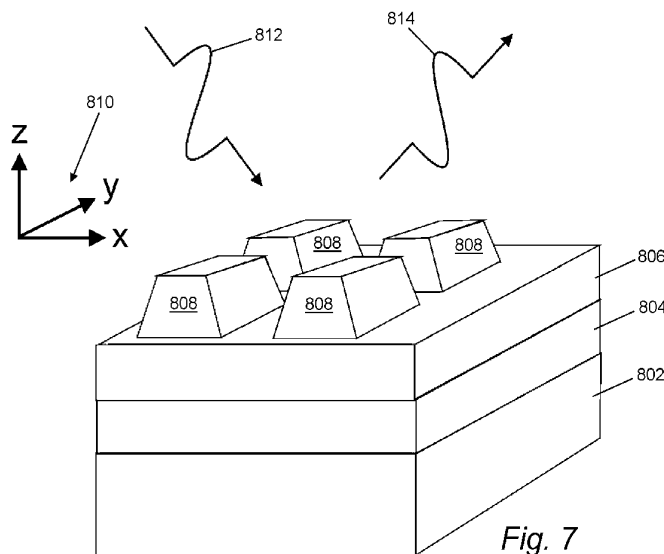


Fig. 7



PARTIAL EUROPEAN SEARCH REPORT

Application Number

under Rule 62a and/or 63 of the European Patent Convention. EP 12 15 8979
 This report shall be considered, for the purposes of subsequent proceedings, as the European search report

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2008/069430 A1 (SETIJA IRWAN DANI [NL] ET AL) 20 March 2008 (2008-03-20) * the whole document *	11-14	INV. G03F1/00 G03F7/20 G01N21/956 G01N21/47
A	STEPHAN RAFLER ET AL: "Investigation of methods to set up the normal vector field for the differential method", SPIE PROCEEDINGS, THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING - SPIE, BELLINGHAM, WASHINGTON, USA, vol. 6995, 25 April 2008 (2008-04-25), pages 69950Y-1, XP002619830, ISSN: 0277-786X, DOI: 10.1117/12.780482 * the whole document *	11-14	
A	MELISEW TEFERA BELACHEW: "Preconditioning Dense Complex Linear Systems from a VIM Discretization", THESIS TECHNISCHE UNIVERSITEIT EINDHOVEN,, 1 August 2009 (2009-08-01), pages 1-93, XP007916546, * the whole document *	11-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			G03F G01N
INCOMPLETE SEARCH			
The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.			
Claims searched completely :			
Claims searched incompletely :			
Claims not searched :			
Reason for the limitation of the search: see sheet C			
Place of search Munich		Date of completion of the search 18 October 2012	Examiner von Hentig, Tanja
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

1
EPC FORM 1503 (03.02) (P04E07)



PARTIAL EUROPEAN SEARCH REPORT

Application Number
EP 12 15 8979

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	<p>THOMAS SCHUSTER ET AL: "Normal vector method for convergence improvement using the RCWA for crossed gratings", JOURNAL OF THE OPTICAL SOCIETY OF AMERICA A, OPTICAL SOCIETY OF AMERICA, US, vol. 24, no. 9, 2 September 2007 (2007-09-02), pages 2880-2890, XP007916629, ISSN: 1084-7529, DOI: 10.1364/JOSAA.24.002880 [retrieved on 2007-08-21] * the whole document *</p> <p style="text-align: center;">-----</p>	11-14	
			TECHNICAL FIELDS SEARCHED (IPC)

**INCOMPLETE SEARCH
SHEET C**Application Number
EP 12 15 8979

Claim(s) completely searchable:
11-14

Claim(s) not searched:
1-10, 15

Reason for the limitation of the search (non-patentable invention(s)):

The subject-matter of claims 1-10 could not be regarded as an invention within the meaning of Article 52(2)(a) EPC, since the subject-matter of those claims is regarded as a scientific theory comprising a mathematical theory (Rule 63(1) EPC).

In other words, the subject-matter of claims 1 to 10 merely relates to a mathematical algorithm of numerically solving a volume integral equation for a contrast current density, i.a. the subject-matter relates to a purely abstract or intellectual method without revealing a technical effect.

The same objection applies, mutatis mutandis, to independent "computer"-claim 15 that refers to the method of above mentioned claims 1 to 10, because there is no "further technical effect", i.a. an effect going beyond that which any program causes, when run.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 15 8979

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-10-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008069430 A1	20-03-2008	JP 4767924 B2	07-09-2011
		JP 2008042202 A	21-02-2008
		US 2008069430 A1	20-03-2008

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82